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(General article)

Pumping System Performance: An Empirical Case Study

Nishant Aggarwal[a*], Dinesh Khanduja[a]

[a]Department of Mechanical Engineering, National Institute of Technology, Kurukshetra(136119)

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Abstract

Proper selection of a tube well viz. submersible type, diesel run type, electricity run type is essential for good life of tube well & its appropriate utilisation. There are certain factors which affect the water distribution in the tube wells. The present study in the Roorkee tehsil of Hardwar district, Uttarakhand, has been taken to meet out the objectives related to performance evaluation of pumping systems. The relevant data & information related to ground water pumping system has been collected from the field. The data has been utilised to analyse the existing pumping systems for which various parameters namely owner's details, tube well details including the year of installation, total cost incurred, boring & pipe depth, pipe material, manufacturing place etc. & pumping unit details including the input/ output power, voltage supply, current supply, rated frequency, rated efficiency have been taken. Paper shows the use of various tubewell types in 8 villages of Roorkee tehsil & comparing the average boring depths & average output power incurred from them. Precising the water table values at different places & how the table has lowered down with time. Comparing various parameters like operation & maintenance, performance appraisal, interaction factor, quality & use of solar powered pumping systems among 8 villages. No. of pumps used, of which how many are defective or dry & the various methods to improve their efficiencies.

Keywords: *Pump efficiency, boring depth, output power, per capita land owned, per capita in tubewell, submersible, diesel run & electricity type tubewell, maintenance, performance.*

1. Introduction

[1]When many people think of a water source, they think of lakes, rivers and streams; in other words, surface water. However, of all of the usable freshwater in the world, approximately 97% of it is groundwater. According to the United Nations, 10 million cubic kilometres of water are stored underground. The United States Geological Survey states that there is about 4.2 million cubic kilometres of water within 0.8 kilometre of the earth's surface. Environment Canada cites a study that estimates that all of the groundwater in the world would cover the surface of the earth to a depth of 120 metres, while all of the surface freshwater would only cover the earth to a depth of 0.25 metre! While groundwater estimates can vary, scientists agree that there is a lot of water under the earth's surface! Mody J.D (1989) gave "Role of customers in Development of Submersible Pumps"; Pant, Niranjan. (1986) detailed Farmer's organization in large irrigation projects; Dunne, T. and L. Leopold, 1978, discussed "Water in Environmental Planning".A well drilled in Summer, normally shows a low yield which is likely to improve in the monsoon. Similarly, a well drilled in October may even become dry in summer.

Pump performance

The work performed by a pump is a function of the total head and of the weight of the liquid pumped in a given time period. Pump shaft power (P_s) is the actual horsepower delivered to the pump shaft, and can be calculated as follows:

Pump shaft power

P_S = Hydraulic power h_P / Pump efficiency (η_{pump})
or

Pump efficiency

η_{pump} = Hydraulic power / Pump shaft power

Pump output, water horsepower or hydraulic horsepower (h_p) is the liquid horsepower delivered by the pump, and can be calculated as follows:

*Corresponding author's email: nishant.aggarwal.nitk@gmail.com

Hydraulic power

$$h_p = Q\ (m^3/s) \times (h_d - h_s \text{ in m}) \times \rho\ (kg/m^3) \times g\ (m/s^2) / 1000$$

Where:
Q = flow rate
h_d = discharge head
h_s = suction head
ρ = density of the fluid
g = acceleration due to gravity

Study area

Climate

The climate of the area is tropical monsoon with four distinct seasons: Summer- March to May, Monsoon- June to September, Post-monsoon-October to November & Winter- December to February marked. Climate is composite, hot during summer, cold during winter & humid during monsoon season. Average maximum & minimum temperatures in January are 20.2 ^{0}C & 6.5 ^{0}C & corresponding temperatures in July are 37.6 ^{0}C & 23 ^{0}C. The average annual sunshine duration is 2800 hrs.

Rainfall

The area forms part of semi-arid tract & receive rainfall by south-west monsoon season. The annual rainfall is about 1050 mm. out of which major amount occurs during south west monsoon in the months of June to September.

Soil Type

In the Roorkee tehsil, the soil type is alluvium, sandy loam to clay loam. The topography has played a more dominant role than climate & vegetation in the formation of the soils.

Figure 1: Map of Study Area- Roorkee

Agriculture

There are 2 cropping seasons namely KHARIF from June to December & RABI from December to May in practice. The major Kharif crops are paddy, maize & main Rabi crop is wheat. Sugarcane is also extensively cultivated. The largest area is covered by wheat followed by sugarcane, paddy, maize, pulses, groundnut & cotton. Production of sugarcane provides good commercial prospects. Irrigation plays an important role in bringing more area under cultivation. Tube wells & canals are the important source of irrigation in the area.

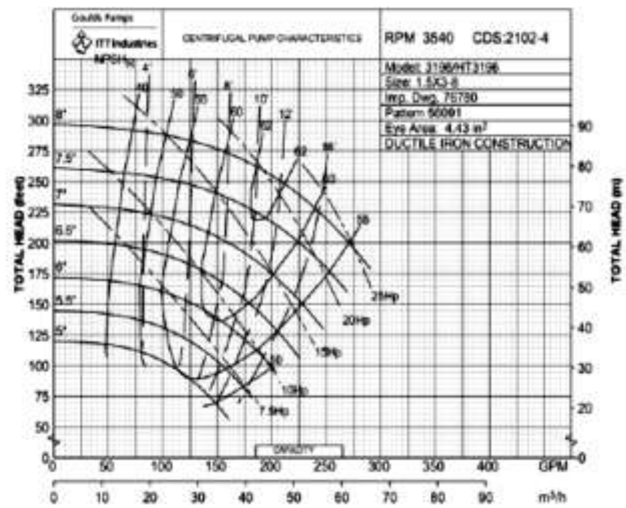

Figure 2: Centrifugal Pump Characterstics (Efficiency curves)

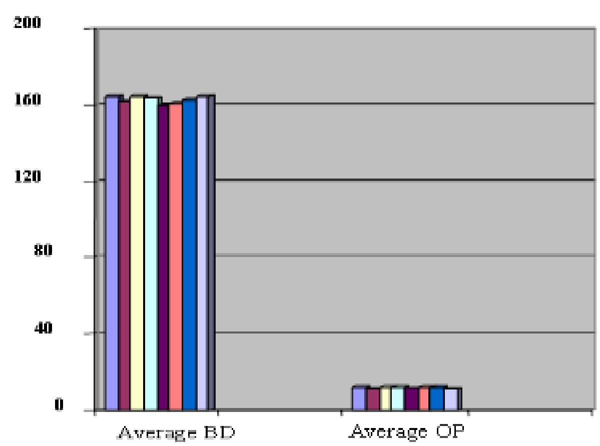

Figure 3: Comparative study of average boring depth (feet) & average output power (KW) for the 8 villages

Data collection

The data has been collected for the Roorkee tehsil, consisting of 8 tube wells for each 8 different villages.

The 8 different villages are- a) Landhaura, b) Dhandera, c) Bhagwanpur, d) Nagla imarti, e) Kaliyar, f) Laksar, g) Manglaur, h) Gurukul narsan

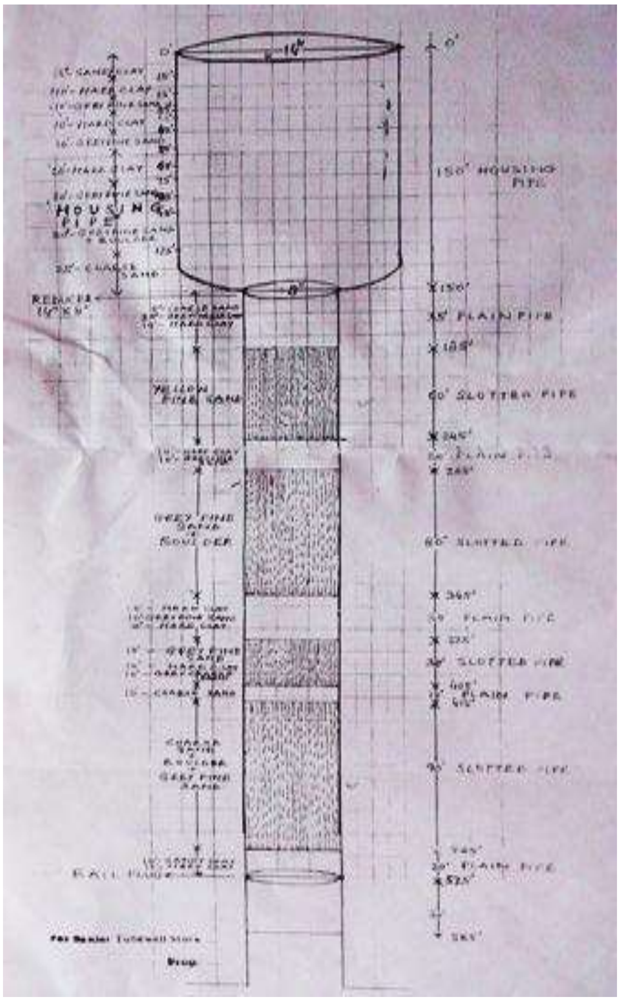

Figure 4: Strata chart of tubewell at IIT roorkee campus Amod Kunj behind church, IIT Roorkee

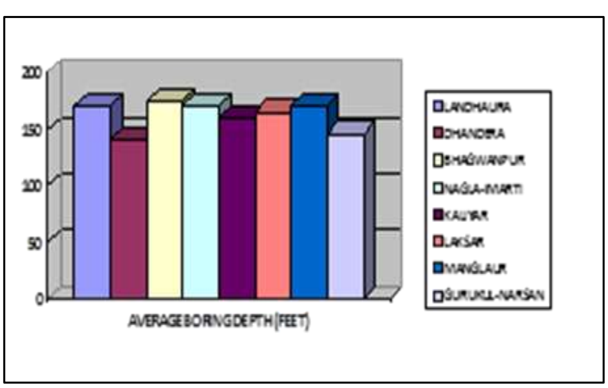

Figure 5: Comparative Average boring depth (feet) for 8 villages

Results & discussions

General

The present study in the Roorkee tehsil of Hardwar district, Uttarakhand, has been taken to meet out the objectives related to performance evaluation of pumping systems. The relevant data & information related to ground water pumping system has been collected from the field. The data has been utilised to analyse the existing pumping systems for which various parameters namely owner's details, tube well details including the year of installation, total cost incurred, boring & pipe depth, pipe material, manufacturing place etc. & pumping unit details including the input/ output power, voltage supply, current supply, rated frequency, rated efficiency have been taken. Water discharging capacity is larger for the diesel pump type tube well running for a larger time without any fatigue.

Pumping system evaluation

The heart of most irrigation systems is a pump. Pumps used for irrigation in the villages include centrifugal, deep well turbine, submersible & propeller pumps. Pump motors used are of 2 types:-Dry motors & Wet motors. A deep drilled tube well site was recommended up to a depth of 60m, plus or minus 10m based on the interpretation. The draw down is an important parameter to be considered for the selection of the pump. The pump selected based on the draw-down consideration works well during the whole year. However, it may give lower efficiency during winter & rainy seasons as the head requirement is low in these days. The pumps are equipped with a mechanical seal which is lubricated by the liquid being pumped. Two positive factors of the tube wells are its good discharge and a longer duration of availability of electricity. With the use of HYV seeds and chemical fertilizers, the adequate and timely supply of water is very important for the growth of the plants. In the case of all the villages except Manglaur & Nagla-Imarti, both these conditions are met. Water discharging capacity is larger for the diesel pump type tube well running for a larger time without any fatigue only consuming diesel. Maintenance of submersible type tube wells & open type tube wells is maximum while the maintenance of diesel type pump tube well is the least with least lubrication required but its negative point is high air pollution due to smoke coming out. This is a part of awareness among the owners of the tube wells & the farmers having such irrigational facilities, mainly in the regions of Nagla-Imarti, Landhaura, Kaliyar. High performance is for the diesel type pump tube well with maximum water discharging capacity & can work for the maximum time in a year with very high rated efficiencies. This is easily found out in Dhandera, Laksar & Landhaura. As the water level is going down day by day, shallow wells are now costly & obsolete. So, the submersible pumps are now widely popular due to their simplicity of design & low cost.

Benefits faced by the farmers using the submersible pump tube wells in the villages like Gurukul-Narsan, Kaliyar are:-

1. Higher overall efficiency.
2. Reduction in civil works with no foundation, pump house, security etc.
3. Self-priming since submerged.
4. Noise & smoke free operation & thus prevents environment from noise & air pollution.
5. Elimination of 2 stage pumping.
6. Can be operated by generator sets in remote areas.
7. Lighter in weight hence easier to install.
8. No need of periodic lubrication.

Operation & Maintenance

The routine operation of the tube well is done by the secretary (security guard) as there is no other operator for the tube well. As regards the upkeep of the distribution system, it has been decided that each beneficiary will clean and maintain the field channel irrigating his field. In addition, in the case of loop 'B', the outlet presidents are also responsible for the safety and upkeep of outlets and other water distribution micro structures. Maintenance of submersible type tube wells & open type tube wells is maximum while the maintenance of diesel type pump tube well is the least with least lubrication required but its negative point is high air pollution due to smoke coming out.

Performance Result

With better water management, there is a crop diversification from traditional to modern cropping patterns. High performance is for the diesel type pump tube well with maximum water discharging capacity & can work for the maximum time in an year with very high rated efficiencies.

Quality of Local Leadership

The local leadership tries to take all sections of water users, representing basically different caste affiliations with them. The secretary is a cool and persuasive person who rises above caste and factional affiliations in matters of management of the tube well society. Thus, taking various factional and caste groupings with him has been a hallmark of the quality of the management leaders, particularly of the secretary. According to the Executive Engineer, the deep attachment and affinity of the secretary with the tube well on account of close physical proximity of the main tube well structure and ownership of large land holdings in the tube well by his family members have greatly contributed to the success of the spread of ground water pumping systems. This scenario is easily found out in Dhandera, Laksar & Landhaura.

Greater Interaction with Support Agency Staff

A high degree of interaction and more frequent contacts between the officers and the farmers is another factor responsible for the success of Groundwater Pumping System (GWPS). Officers have been holding several meetings with the farmers, both with respect to their present strategy and future plan. It has been found that the initial encouragement and guidance from senior officers and the close involvement of the field staff to educate, aid and advise the farmers is taken up, for such water cooperatives to succeed. This scenario is easily found out in Gurukul-Narsan, Laksar, Landhaura & kaliyar.

Solar Powered Groundwater Pumping System

Solar-powered groundwater pumping systems are often considered for use in livestock and other remote watering applications instead of other forms of alternative energy because they are durable, mobile, and exhibit long-term economic benefits. Generally, alternative power is only considered when the cost of tapping into the closest public power grid far, outweighs the costs of using alternative power. There are several technology alternatives for supplying power, or lift, to groundwater systems including:- wind turbines, windmills, generators, and solar arrays. The driving factors for selecting the appropriate technology are regional feasibility, water demand, system efficiencies, and initial and long-term costs. Other factors often include the need for power and water reserves in the form of batteries and livestock tanks. The selection of solar-powered pumping systems (SPPS) should only follow a thorough look at the feasibility and future prospect of the technology. The cost of implementing a SPPS can be significantly more than the expenses of connecting to the local power grid.

Table 1 Pros & Cons of Alternative Forms of Energy

Alternative forms of energy	pros	cons
Generator	-Moderate initial cost -Easy to install	-High maintenance, expertise required for repair -Short life expectancy (5 years) -Fuel is expensive
Wind turbine	-Lower initial costs than SPSS -Long life expectancy -Effective at windy sites -Clean -No fuel needed	-High maintenance needs -Expensive repair -Parts difficult to find -Wind can vary seasonally and daily -Lower output in calmer winds
Solar powered pumping systems (SPPS)	-Easy to install -Can be mounted on trailer to accommodate moving livestock -Long life expectancy	-Solar energy can vary seasonally -Higher initial cost -Lower output in cloudy weather

Conclusions

The study has led to the following conclusions:

- Out of various types of pumps, centrifugal pumps are the most popular for water wells which can be sub-divided into 2 categories:-
  1. Shallow well pumps used to lift water from depths of less than 7.5m,
  2. Deep well pumps used to lift water from depths exceeding 7.5m.
- The pump fails to pump the water when the head required is increased due to draw-down during the summer season.
- Pumps made by Kirloskar oil engines ltd. Pune are waterproof. Pump life is high as they are casting graded & SS-410 shaft which does not rust.
- The plot of average boring depth (feet) shows that the average bored depths are nearly the same with the highest in Landhaura & Bhagwanpur regions with 164.75 feet.
- The plot of average output power supply (KW) shows that the average power supply is nearly the same with the highest of 11.475 KW in Laksar.
- SPPS & other alternative pumping type of system can rarely be installed in India as we are not having a complete knowledge about this project so as to install in different parts of our country. Still as a matter of fact, in villages like Gurukul-Narsan, Landhaura, Kaliyar, where there is large population of tube well users with well-equipped technologies, SPPS can extend its arms to provide more sophisticated & beneficial irrigational & drinking facilities.
- Out of all the 64 pumps, 16 pumps are not working satisfactorily & needs new machinery.

Options to improve energy efficiency of pumps and pumping systems are:

- Operate pumps near their best efficiency point (BEP)
- Modify pumping system and pumps losses to minimize throttling.
- Ensure availability of basic instruments at pumps like pressure gauges, flow meters.
- Adapt to wide load variation with variable speed drives or sequenced control of multiple units.
- Avoid operating more than one pump for the same application.
- Use booster pumps for small loads requiring higher pressures.
- To improve the performance of heat exchangers, reduce the difference in temperature between the inlet and outlet rather than increasing the flow rate.
- Repair seals and packing to minimize water loss by dripping.
- Balance the system to minimize flows and reduce pump power requirements.
- Avoid pumping head with a free-fall return (gravity), and use the siphon effect.
- Conduct a water balance to minimize water consumption, thus optimum pump operation.
- Avoid cooling water re-circulation in DG sets, air compressors, refrigeration systems, cooling towers feed water pumps, condenser pumps and process pumps.
- In multiple pump operations, carefully combine the operation of pumps to avoid throttling.
- Replace old pumps with energy efficient pumps.
- To improve the efficiency of oversized pumps, install variable speed drive, downsize / replace impeller, or replace with a smaller pump.
- Optimize the number of stages in multi-stage pump if margins in pressure exist.
- Reduce the system resistance by pressure drop assessment and pipe size optimization.

- Regularly check for vibration to predict bearing damage, misalignments, unbalance, foundation looseness etc.

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